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Procedures for the Improvement of Roasted Coffees:

In order to improve the quality of roasted coffees - particularly their organoleptic characteristics - acidity levels of the green (unroasted) coffee beans are increased. This increase in acidity is achieved primarily through the impregnation of these unroasted coffee beans in an aqueous solution of the appropriate types of acid. This impregnation procedure results directly in a substantial increase in the quantities of titratable acidic materials present within the roasted-coffee products, and, thereby, to significant enhancement of taste, aroma and coloration characteristics.

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PATENT CLAIMS

1.) Procedures for the qualitative - particularly organoleptic - improvement of roasted coffees, characterized by the fact that the acidity levels of the green (unroasted) coffee beans are increased by preliminary treatment, and are then roasted.

2.) The procedures described above, in Claim #1, further characterized by the fact that the raw coffee beans are initially treated with either acids or acid-reactive salts.

3.) The procedures described above, in either Claim #1 or Claim #2, further characterized by the fact that the raw coffee beans undergo initial treatment with acids in aqueous solution.

4.) The procedures described above in Claim #1, and also in one or more of Claims #2 or #3, further characterized by the fact that the aqueous solutions in which the raw coffee beans undergo initial enrichment processing contain acetic acid and/or phosphoric acid and/or citric acid.

5.) The procedures described above in Claim #1, as well as the procedures described in one or more of Claims #2 through #4, further characterized by the fact that the precise quantity of aqueous acid-bearing solution employed in a given raw-coffee-bean enrichment procedure, as well as the precise concentration levels of solution component substances, are pre-established in such a way that the treatment solution is fully absorbed into the coffee beans upon completion of enrichment processing.

6.) The procedures described above in Claim #1, as well as the procedures described in one or more of Claims #2 through #5, further characterized by the fact that the mass of the enrichment solution in any given treatment operation falls within the general range of 0.2 times - 0.9 times the dry weight of the raw coffee (bean) material which is to undergo enrichment processing, approximately; optimum results are frequently obtained with the use of approximately 0.5 times the total coffee dry weight of the aqueous enrichment solution. Exemplary values for acidic-substance concentration within the enrichment solution are generally within the range of 0.005 times to 0.025 times the total coffee-material dry weight.

7.) The procedures described above in Claim #1, as well as the procedures described in one or more of Claims #2 through #6, further characterized by the fact that the enrichment of the raw coffee material within the aqueous, acid-bearing treatment solution entails the continuous intermingling of the enrichment solution and the raw coffee beans at a processing temperature higher than room temperature; ideally, processing temperatures should be in the vicinity of 70°C.

8.) The procedures described above in Claim #1, as well as the procedures described in one or more of Claims #2 through #7, further characterized by the fact that, after the enrichment solution in a given treatment operation has been fully absorbed into the raw coffee beans, and prior to the initiation of roasting procedures, the moisture-content level of the coffee material is returned to its original (pre-treatment) value through the use of certain drying procedures.

9.) The procedures described above in Claim #1, as well as the procedures described in one or more of Claims #2 through #8, further characterized by the fact that the aqueous treatment solution contains, in addition to water and the necessary acidic substances, the appropriate quantity of an extract comprising all of the water-soluble materials found within the untreated, raw coffee beans in order to establish and maintain an equilibrium state between these water-soluble materials within and outside of the coffee beans undergoing enrichment treatment, thereby preventing the passage of these materials from the coffee beans into the surrounding liquid medium, and their consequent loss.

10.) The procedures described above in Claim #9, as well as the procedures described in one or more of Claims #1 through #8, further characterized by the fact that, prior to the initiation of the enrichment treatment in the aqueous solution, the raw coffee beans are subjected to saturation with water; in this way, a water/water equilibrium state is established, and maintained throughout the course of enrichment processing, between the raw coffee material and the treatment solution; this equilbrium complements the water-soluble materials equilibrium described above, in Claim #9.

11.) The procedures described above in Claims #1 and #9, as well as the procedures described in one or more of Claims #2 through #8 and #10, further characterized by the fact that the aqueous acid-bearing enrichment solution (containing the extract of water-soluble coffee materials) is constantly recirculated, within a closed circulation system, through the container holding the raw coffee material. Acidity levels are constantly monitored for both enrichment solution and coffee materials, and supplementary acidic substances are added to the circulating solution as required. When the pre-determined acidity level of the coffee beans has been established, the enrichment procedure is concluded.

12.) The procedures described above in Claim #11, as well as in one or more of Claims #1 through #10, further characterized by the fact that the quantity of acidic material added to the circulating enrichment-solution stream is carefully measured.

13.) The procedures described above in Claim #1, further characterized by the fact that the increase of the acidity of the raw coffee beans is brought about through the use of certain microbiological techniques - in particular, through treatment with enzyme substances.

14.) The procedures described above in Claim #1, further characterized by the fact that the increase of the acidity of the raw coffee beans is achieved through the use of thermal hydrolysis - that is, through heating of the coffee material, in the presence of high atmospheric-moisture levels, to a temperature of more than 130°C.

15.) The procedures described above in Claim #1, further characterized by the fact that the increase of the acidity of the raw coffee beans is attained by means of the exposure of raw-coffee extract to ion-exchange procedures, followed by successive reintegration and drying.

16.) The procedures described above in Claim #1, further characterized by the fact that the increase of the acidity of the raw coffee beans is attained through the application of electrodialytic treatment to raw-coffee extract, followed by successive reintegration and drying.

DESCRIPTION

The invention in question here consists of a series of procedures for the improvement of the quality - in particular, of the organoleptic characteristics - of roasted coffees.

The level of quality of a given roasted coffee, and of the coffee beverage which is produced from that particular roasted coffee, is largely dependent upon the quality of the raw coffee beans from which that roasted coffee has been produced. It is well-known that coffees categorized as 'mild' - for instance, 'Colombia mild' - are generally high-quality coffees with exceptionally pleasant taste characteristics. However, certain 'mild' coffees, such as 'Brazilian mild', and others, such as 'Robusta', are much less high regarded in these respects.

In view of the fact that the established quality level of a particular coffee type is almost always directly reflected in its purchase price, it is obviously of great potential advantage for the producers of roasted coffee for consumer use to implement effective procedures for imparting to less expensive, lower-quality coffees the desirable taste, aroma and coloration characteristics exhibited by more expensive and highly-regarded coffees. In the past, the research work carried out with this specific end in view was limited almost exclusively to the roasting process itself, and to the coffee product after roasting had been completed. With this end in view, such variant roasting technique as 'pressure roasting' and 'quick-roasting' were developed. However, none of these previous developments resulted in substantial practical benefits with regard to coffee-taste 'upgrading'.

The chief aim of the present invention consists in the qualitative improvement of roasted coffees - in particular, the qualitative 'upgrading' of less highly-regarded coffee types.

This qualitative coffee upgrading is achieved, in the procedures described in the present invention, through the increase of the acidity levels of the raw coffee beans, prior to roasting; such enrichment procedures involve the exposure of the coffee beans to an aqueous, acid-bearing enrichment solution.

The enrichment of the raw coffee beans with acidic materials has been found to generate a variety of distinctly beneficial effects upon the resultant roasted-coffee product, and the coffee beverages derived from such roasted coffees. Such benefits include significant upgrading of taste, aroma and coloration characteristics.

One of the most important and reliable benchmarks for the determination of the quality of a given coffee is its acidity level. Such values for acidity levels of coffee are generally expressed in terms of pH value, and/or in terms of titratable acidic materials present (ml/100g). In Table #1, below, acidity levels of both types are provided for coffees of various provenances.

TABLE #1

Coffee type (Provenance)	Titratable acids(ml/100g)	pH value
Colombia milds(Kenya)	32	5.0
Other milds(Guatemala)	29	5.1
Brazilia mild(Santos)	25	5.4
Robusta(Ivory Coast)	19	6.1

[All test samples: Drip-filter brew: 60 g/l; color value: 10 agtron units.]

In the evaluation of the quality, and particularly the taste characteristics, of the various coffees listed in Table #1, it should be reiterated that higher acidity levels, and the associated lower pH values, are almost always reliable indications of high-quality, pleasant-tasting coffee.

The present invention provides a means of increasing the original acidity levels of raw coffee beans - and, in turn, of the resultant roasted coffees and coffee beverages. By this means, from relatively inexpensive coffee beans, coffees with the taste characteristics of more expensive and more highly-regarded coffees can be produced.

The acidic material(s) present within the aqueous enrichment solution must, naturally, be acids which naturally occur in the coffee beans in question, such as, for instance, acetic acid and/ or citric acid. The acids employed in these enrichment solutions must possess an acceptable level of thermal stability as well as a relatively low level of volatility. Particularly good results in such enrichment procedures have been obtained through the use of phosphoric acid and citric acid. The acidity levels of raw coffee beans can also been effectively enhanced through the use of acid-reactive salts of various types. Such acid-reactive salts are introduced to the coffee materials within an aqueous solution, as are the various enrichment acid materials. Both calcium phosphate and calcium citrate are acid-reactive salts which have been proven effective in applications of the type in question here.

The supplemental acid materials are, as was mentioned above, introduced to the coffee materials within an aqueous solution. Two separate treatment procedures have yielded particularly good results in the acid supplementation of raw coffee beans.

In one of these effective enrichment procedures, the quantity of solution to be employed in a given operation is carefully calculated and prepared in advance. This quantity of solution is precisely that required to generate the required acidity enhancement in the coffee materials; when the solution has been completely absorbed into the coffee beans, the enrichment procedure is concluded.

In operations of this type, the total mass of the enrichment solution should not exceed 0.9 times the dry weight of the coffee material which is to undergo treatment. Ideally, the solution weight should be approximately 0.5 times the dry weight of the coffee beans which are to be enriched in a given operation. The quantity of acidic material within the enrichment solution should fall within the range of 0.005 to 0.025 times the dry weight of the coffee material which is to undergo enrichment.

In order to ensure an optimum level of distribution of the acidic supplementary materials throughout the coffee-bean cluster, preliminary processing is carried out within a mixer apparatus: here, the raw coffee beans and the enrichment solution are subjected to continuous mixture-agitation throughout the entire treatment process. A typical enrichment process might be carried out within the mixer apparatus, at a temperature of 70°C, for a period of 2 hours. Alternatively, the raw-coffee charge can be continuously conveyed (through the use of a special transport mechanism) to a site at which it is brought into contact with the recirculating stream of enrichment solution; both coffee and enrichment solution are kept in constant motion within this variant treatment system, until the desired coffee-bean acidity levels have been attained. A pump is employed for the circulation of the enrichment solution. The processing is concluded, as above, when the enrichment solution has been completely absorbed into the coffee material.

The second general type of enrichment-processing regimen at issue here involves the use of a quantity of enrichment solution which is greater than the amount required for absorption into a given raw-coffee charge. In procedures of this type, the quan-

tity of enrichment solution employed is carefully selected in such a way that the continuous sprinkling or spraying of the coffee beans with solution is possible. Continuous circulation of the enrichment solution ensures a homogeneous deposition of the acidic materials within the coffee beans. In order to eliminate the danger of the escape of water-soluble materials from the coffee beans into the aqueous enrichment solution during processing, an equilibrium state is established, and maintained throughout enrichment processing, between the water-soluble materials within the coffee beans and the same materials present (in the form of a supplementary extract) within the enrichment solution. Solution quantities and concentration levels are also carefully pre-selected and -established in such a way that an additional, complementary water/water equilibrium is established between enrichment solution and coffee material: to this end, the coffee-material charge is subjected to initial water saturation. These equilibrium states can be successfully maintained even during protracted enrichment processing at the required temperature levels.

The extract material within a given enrichment solution, intended to establish the water-soluble material equilibrium between solution and coffee beans, might consist of 21% dry weight of the total aqueous solution weight, of a coffee-material extract which had been enhanced with the required types and concentrations of acidic materials. This acidic material does not participate in either the soluble-substance equilibrium or the water/water equilibrium between coffee bean and enrichment solution, and therefore is able to pass freely into the interior of the saturated coffee bean from the surrounding solution.

Effecient treatment procedures of this type can be carried out through the use of a system which employs a number of processing containers, each filled with a raw-coffee charge for enrichment. These containers, positioned one behind the other, are successively exposed to the enrichment solution in a continuous treatment process.

For every individual coffee type and coffee-type mixture which is to be subjected to enrichment procedures of this kind, it is necessary to first determine empirically the time during which the given coffee charge must be kept in contact with an enrichment solution of a given acidity level, in order to bring about the required acidity increase in the coffee-charge material.

It is also possible, as a processing alternative, to precisely pre-determine and control the acidity increase which will be brought about in a given coffee charge by means of the careful initial weighing of the acidic material before it is added to the enrichment solution.

Whichever enrichment procedure is selected for use, at the conclusion of the treatment the enriched coffee is subjected to brief water-spraying, in order to remove the acidic material on the outer surfaces of the treated coffeee beans.

After the water-spraying of the enriched coffee beans, drying procedures are employed, in order to return the beans to moisture-content levels (within the general range of 8% - 12%) which they possessed prior to processing in the aqueous enrichment solution. This procedure ensures the suitability of the end-product roasted coffee for extended storage without significant loss of quality. The enriched coffee beans are, at this point, ready for roasting. In most cases, the drying of the coffee beans, after enrichment, involves the use of a stream of heated air; typical drying temperatures are in the vicinity of 120°C.

In addition to the direct enrichment of the coffee beans (that is, the significant increase of their acidity levels) through direct contact with acidic materials in aqueous solution, as described above, a number of alternative techniques have proved successful in bringing about such increases in acidity level, including the following:

.microbiological techniques, including various treatments with bacteria or enzymes;

. thermal hydrolysis - for instance, heating of the coffee charge in an atmosphere with a high moisture level, to temperatures within the vicinity of 130°C;

. the subjection of the raw-coffee extract to ion-exchange processing, followed by reintegration and drying;

. and, finally, the electrodialytic processing of raw-coffee extracts, with subsequent reintegration and drying of the treated material.

All of the procedures mentioned above have proved successful in the increase of acidity levels of lower-quality coffees to a point at which they begin to exhibit many of the valued and favorable characteristics (taste, aroma, coloration) associated commonly with more highly-regarded and expensive coffee types. Such qualitative improvement in these coffees has been provided with quantitative support through the data obtained here in the following types of analyses of sample coffees of various provenances and initial quality levels, both before and after enrichment processing had been carried out. The investigations carried out here included, specifically: studies of concentration levels of titratable acids within given coffee samples (ml/100g); studies of water-soluble coffee material quantities, with particular reference to concentration levels of aromatically-active substances; and coloration studies.

In Table #2, below, typical analytical values are provided for three different types (and quality levels) of unenriched sample coffee material, including: Colombia (high quality); Brazil (medium quality); and Robusta (lower quality). (All test samples in Table #2 were filtered-brewed at 60 g/1, and roasted to 10 agtron units.) It can be seen, in the results provided here in Table #2, that the acidity levels of coffees tend to increase with coffee-type quality (as reflected in lower pH values and higher concentration-level values for titratable acids per unit volume). The values for HMF (hydromethylfurfurol) concentration within the volatile fraction

of each sample roasted-coffee type also reflects a significant increase in association within increased coffee-type quality.

In Table #3, below, values for pH, titratable-acid concentration, HMF level and aroma index are provided for the three coffee types listed in Table #2; in Table #3, results are provided not only for unenriched coffee sample, but also (as a basis for evaluation of the enrichment procedures described herein) for coffee samples enriched with 1% or 2% citric acid.

Experiments carried out with equivalent quantities of H_3PO_4 have yielded analogical results. Aroma-index values listed here were obtained through evaluation of the volatile materials (aromatics) within the ultra-violet region.

A comparative analysis of the data provided here in Table #1 through #3 yields clear and convincing support to the initial statement that the application of materials and procedures of the types described here can lead to the substantial improvement of the quality of treated coffees.

Other comparative studies have indicated that the enrichment of raw coffee beans with acidic materials exerts a significant effect, from a chemical point of view, upon the processes which take place during coffee roasting; this leads directly to the generation of roasted-coffee products which differ significantly, with respect to chemical composition, from their unenriched counterparts. It has been established that, in coffee samples which have been subjected to preliminary enrichment treatment (acidity-level increase), the roasting process generates significantly larger quantities of volatile aromatic materials; more specifically, of specific substance groups within the group of volatile aromatics. The generation of other substance groups, on the other hand, is substantially inhibited by such initial increasing of acidity levels. Volatile aromatics whose concentrations are significantly increased through initial coffee-charge enrichment include the following: furanes in general, and, more specifically, furfural, 5-methylfurfural and hydroxymethylfurfurol (HMF; see Tbale #2 and #3). These volatile aromatic substances exert a significant positive effect upon the generation of favorable taste and aroma characteristics within the roasted-coffee

TABLE #2:

Coffee Type	pH	Titr. Acids	HMF	Aroma-index
Colombia	5.1	29	54	123/147
Brazil	5.4	25	37	90/146
Robusta	6.1	19	15	84/182

* * * * * * *

TABLE #3:

Coffee Type	pH	Titr. Acids	HMF	Aroma-index
Colombia [unenriched]	5.1	29	54	123/147
Colombia [+1% citr. ac.]	4.9	34	112	170/130
Brazil [unenriched]	5.4	25	37	90/146
Brazil [+1% citr. ac.]	5.1	42	87	113/131
Robusta [unenriched]	6.1	19	15	84/182
Robusta [+1% citr. ac.]	5.4	39	29	87/164
Robusta [+2% citr. ac.]	4.7	55	36	92/159

[Enrichment of all samples carried out with citric acid.]

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TABLE #4

(Concentration levels of selected volatiles in Colombia coffees [ppm/kg].)

	Orig.	+2% A	+5% A	+2% B	+0.5% B	+1.5% C
Furfural	68	241	497	160	119	48
2-Acetylfurane	18	19	11	13.5	14	9.7
5-Me-furfural	85	125	94	130	108	62
2-Me-tetrahydrofuran-3-on	20	14.5	7.6	8	11.9	9.7
Total furanes	324	443	630	364	324	256
Total sulphur-bearing furanes	3.2	1	1	0.9	1.36	4.15
Total M-Alkyl-pyrrhole	1.2	0.6	0.4	1.15	1.1	1.38
Total other pyrrhole	16.8	5.7	4.3	4	5.8	8.06
Total thiophene derivs.	6	4.2	1.8	1.65	1.1	3.55
Pyridine	15.5	1.9	-	1.08	7.3	29.3
Total pyrazine	146	32	8	28.5	64	241
Total volat. phenols	29.5	14.4	7.5	15	11.2	27.8
TOTAL AROMA	665	587	722	670	634	845

['A' = citric acid;
'B' = phosphoric acid;
'C' = potassium hydroxide.]

product and the coffee beverages prepared from the roasted coffee. A relatively high concentration level of such volatile furane-group aromatics is characteristic of the expensive, highly-regarded 'Arabica'-type coffees.

Among the substance groups whose generation is significantly inhibited when initial enrichment processing is employed are the following: pyridine; pyrazine; and thiophene. All of these materials have been conclusively demonstrated to exert a negative effect upon coffee aromatic characteristics. In unenriched coffee samples, such materials were found to be present in the highest concentrations in the lower-quality coffees of the 'Robusta' type.

In Table #4, above, the results are provided for an analysis of volatile-substance concentration levels of sample high-quality (Colombia) coffees, both unenriched and enriched with a variety of materials, at various concentration levels.

The enrichment of raw coffee beans with selected acids, as described above, leads directly to the changes in chemical composition provided here in the Tables; volatile-substance concentrations are of particular interest here. In another series of comparison trials, the acidity levels of sample coffees were significantly reduced, prior to roasting, through the initial treatment of the coffee beans with caustic lye. Increased pH values and decreased acid concentration levels were noted immediately; an increased intensity was observed in the Maillard reaction which took place in the course of the roasting process; and significant changes in concentrations of certain volatile fractions were observed in subsequent analysis of the compositions of the resultant roasted-coffee products. For instance, concentration levels of furane materials were substantially reduced; while quantities of pyridine, pyrazine and thiophene increased substantially: all of these compositional changes would tend to make the coffee less pleasing and less favorable in its aromatic characteristics.

The increase in pH value was, therefore, found to exert a substantial negative effect upon the aromatic characteristics of the resultant roasted-coffee product. Enhancement of these

aromatic properties was generated only through the appropriate use of acidic materials in treatment regimens, with the attendant lowering of coffee-bean pH values, and increase in acidity levels, prior to roasting.

Example of Enrichment Processing

The appropriate acid-bearing aqueous solution is prepared, and is heated to a temperature of approximately 70°C. The concentration of the acidic solution is 2.43% (in this case, 0.5kg of citric acid in 20kg water).

50 kg of raw coffee beans (Brzil type) are placed in a heatable extraction apparatus, which is also heated to a temperature of approximately 70°C. The enrichment solution is then circulated through the receptacle containing the raw coffee beans for approximately 1½ hours; the 70°C processing temperature is maintained during this period. The procedure is completed when the circulating solution has been completely absorbed by the coffee beans.

The enriched coffee beans are then placed in a covered, rotary air-drying unit, where drying is carried out for approximately 90 minutes, at a temperature in the vicinity of 100°C. The duration of the drying interval is conditioned by the necessity of restoring to the enriched coffee beans a moisture-content level which approximates their pre-enrichment moisture level (typically, 8% to 12%); this ensures favorable storage characteristics.

Finally, the enriched, dried coffee beans are subjected to roasting following normal roasting procedures.